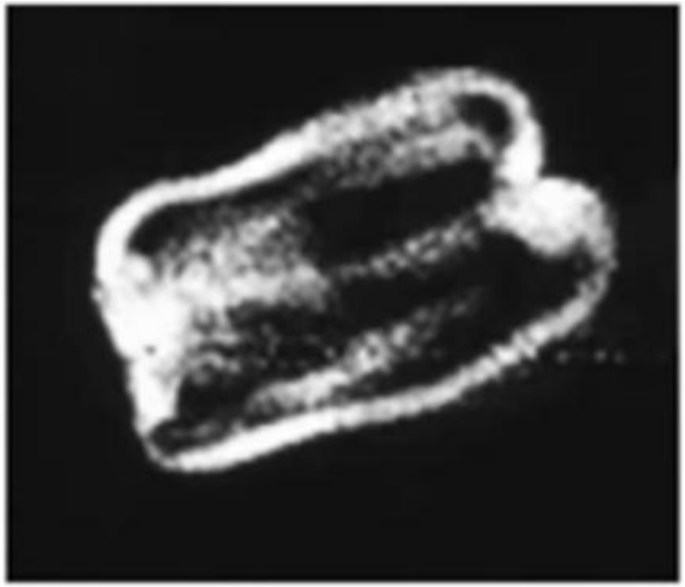
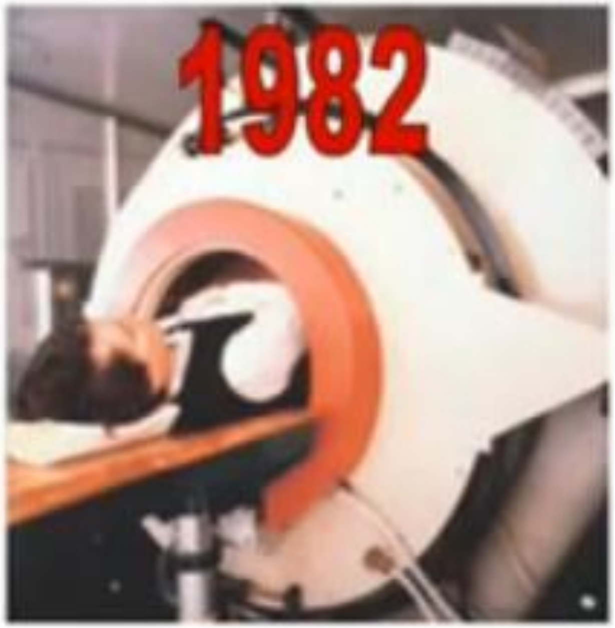
MAGENETIC RESONANCE IMAGINING

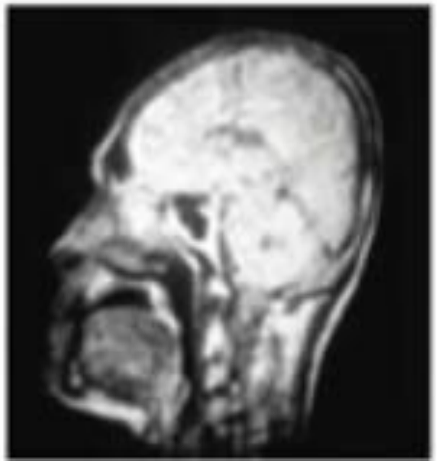
DR. AMAL ELSHAHAWY

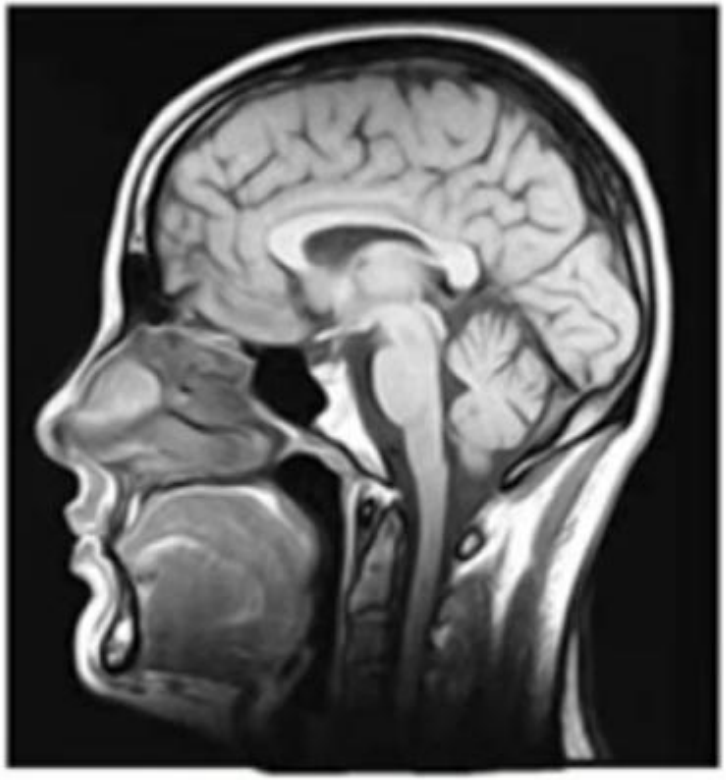


1979



1982





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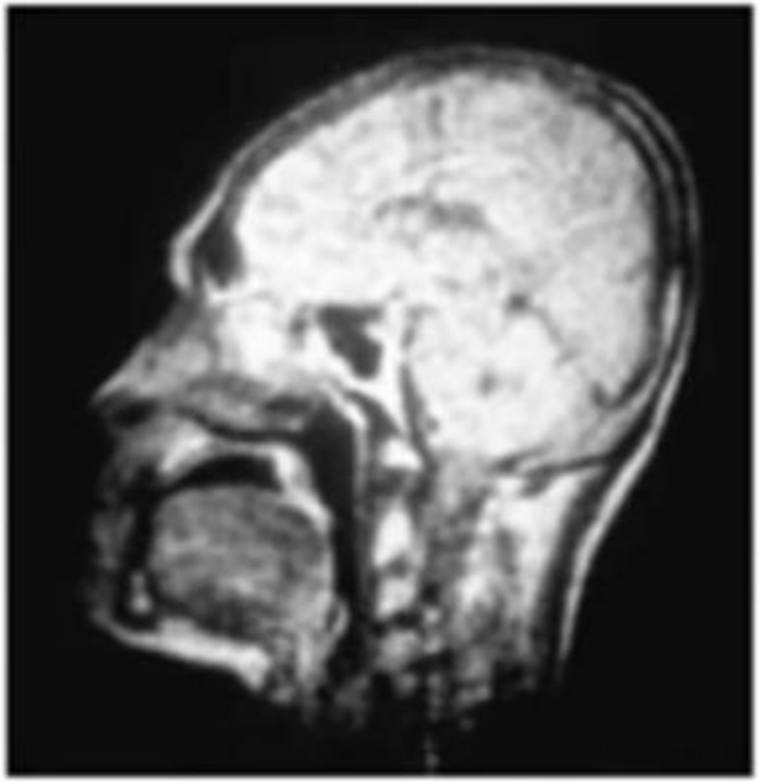


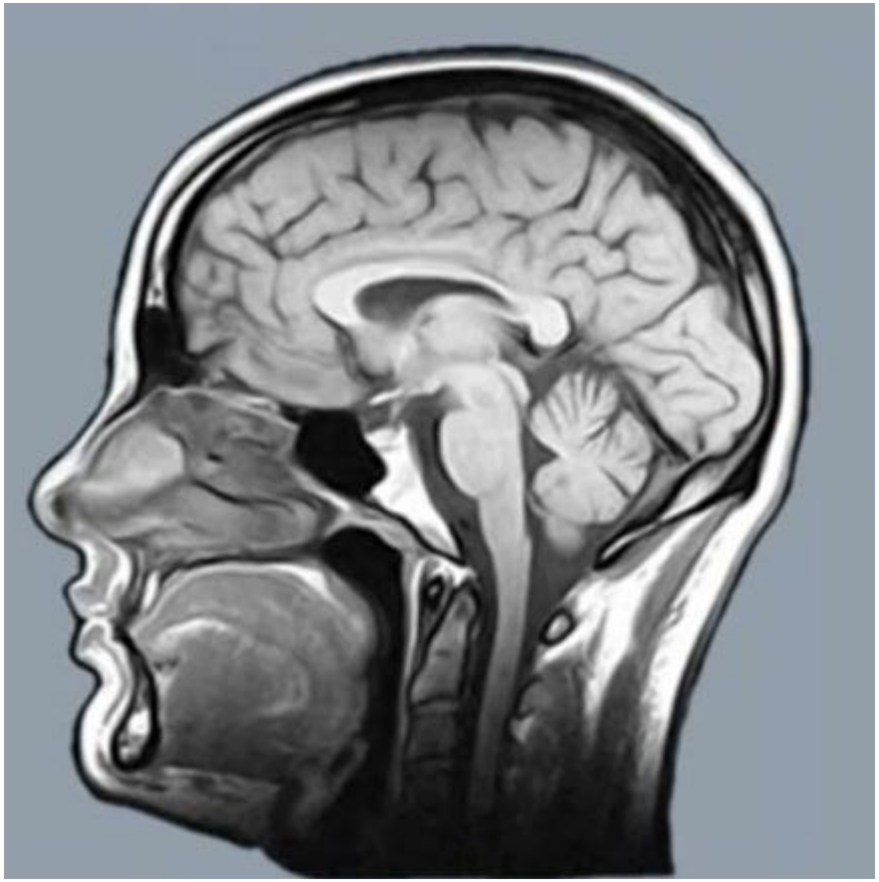
1982

What is MR?

- Magnetic resonance imaging (MRI) is an imaging technique used in medicine to produce high quality images of the inside of the human body.
- MRI is based on the principles of nuclear magnetic resonance (NMR), a spectroscopic technique used by scientists to obtain microscopic chemical and physical information about molecules.

Magnetic resonance imaging (MRI)

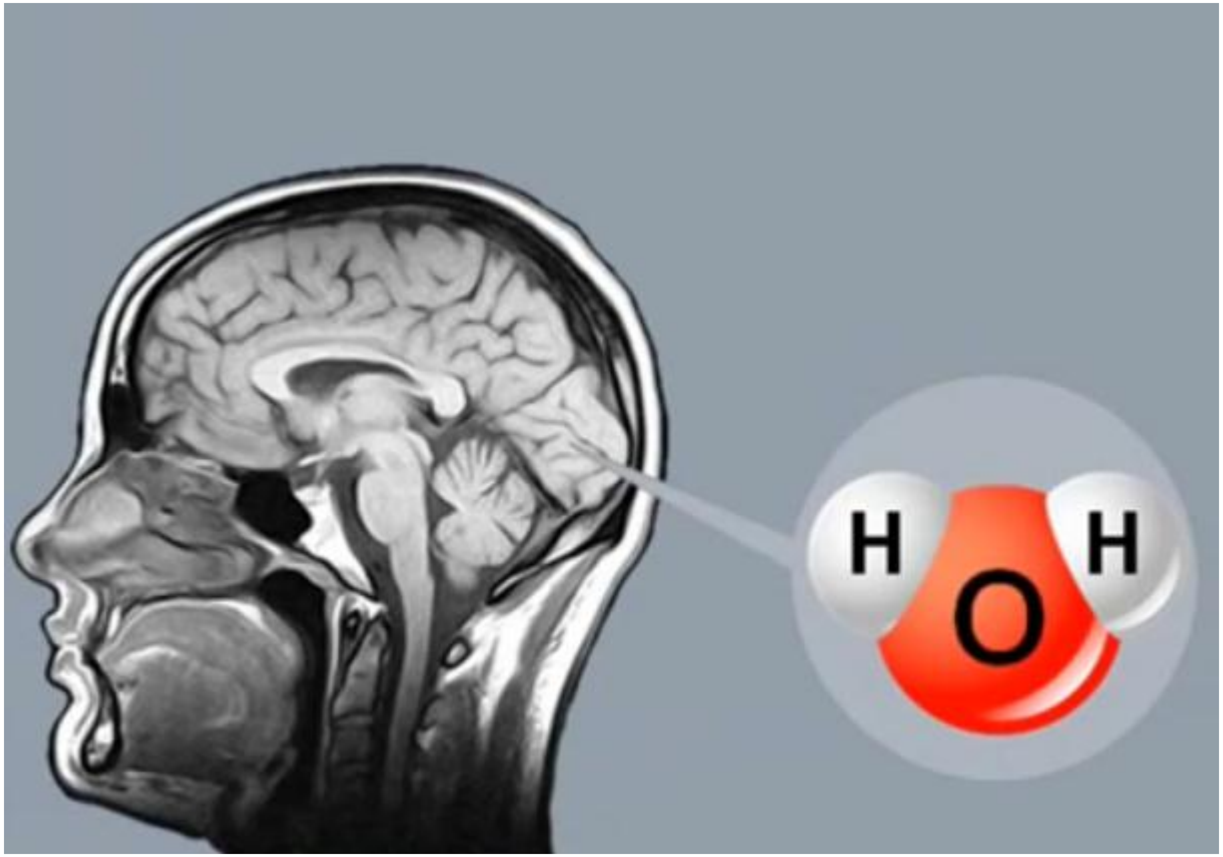
- An MRI (or magnetic resonance imaging) scan is a radiology technique that uses magnetism, radio waves, and a computer to produce images of body structures.

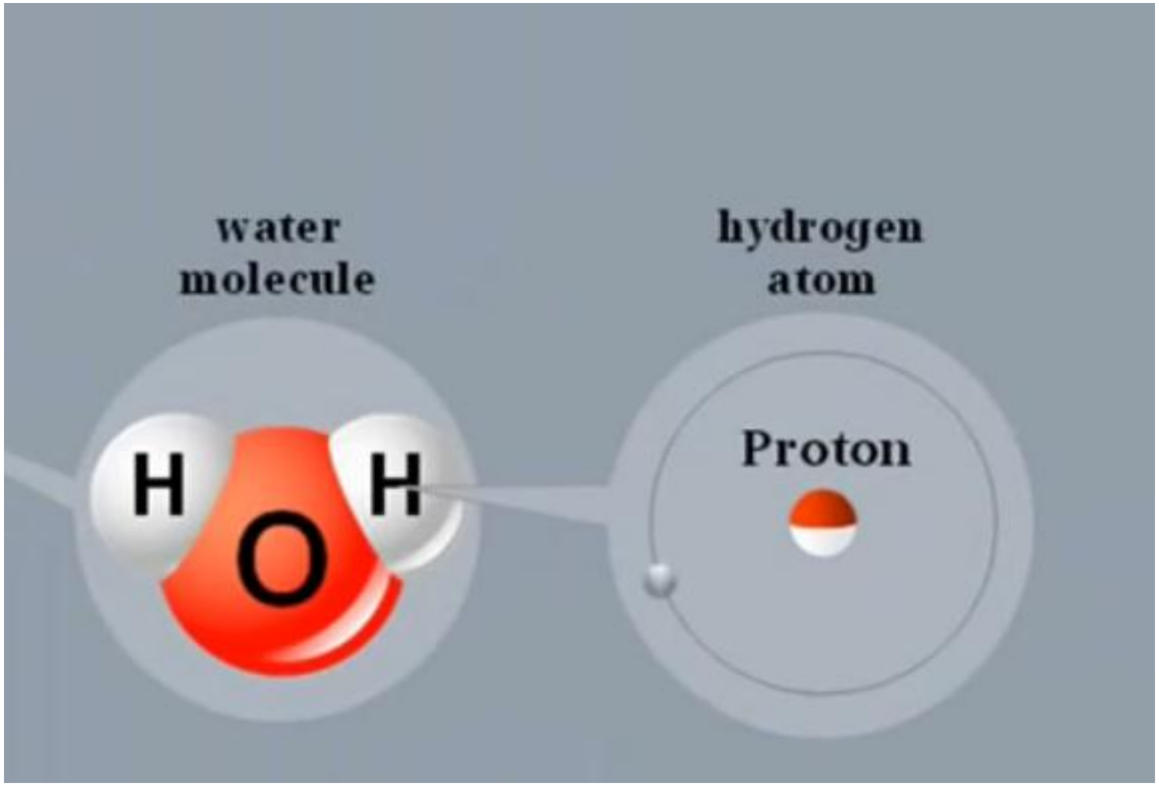


- The human body is primarily fat and water. Fat and water have many hydrogen atoms which make the human body approximately 63% hydrogen atoms.
- Hydrogen nuclei have an NMR signal. For these reasons magnetic resonance imaging primarily images the NMR signal from the hydrogen nuclei.

The hydrogen nuclei behave like compass needles that are aligned by a strong magnetic field in the scanner. The nuclei can be rotated using radio waves.

while returning to equilibrium, they emit a radio signal. This can be used for making images of body tissues

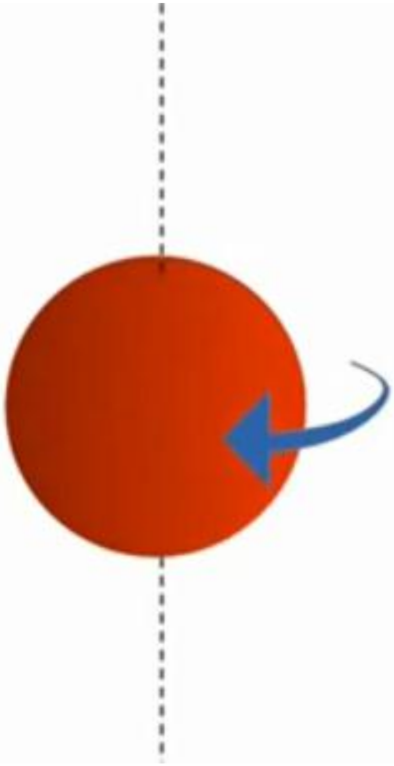

H
O
H

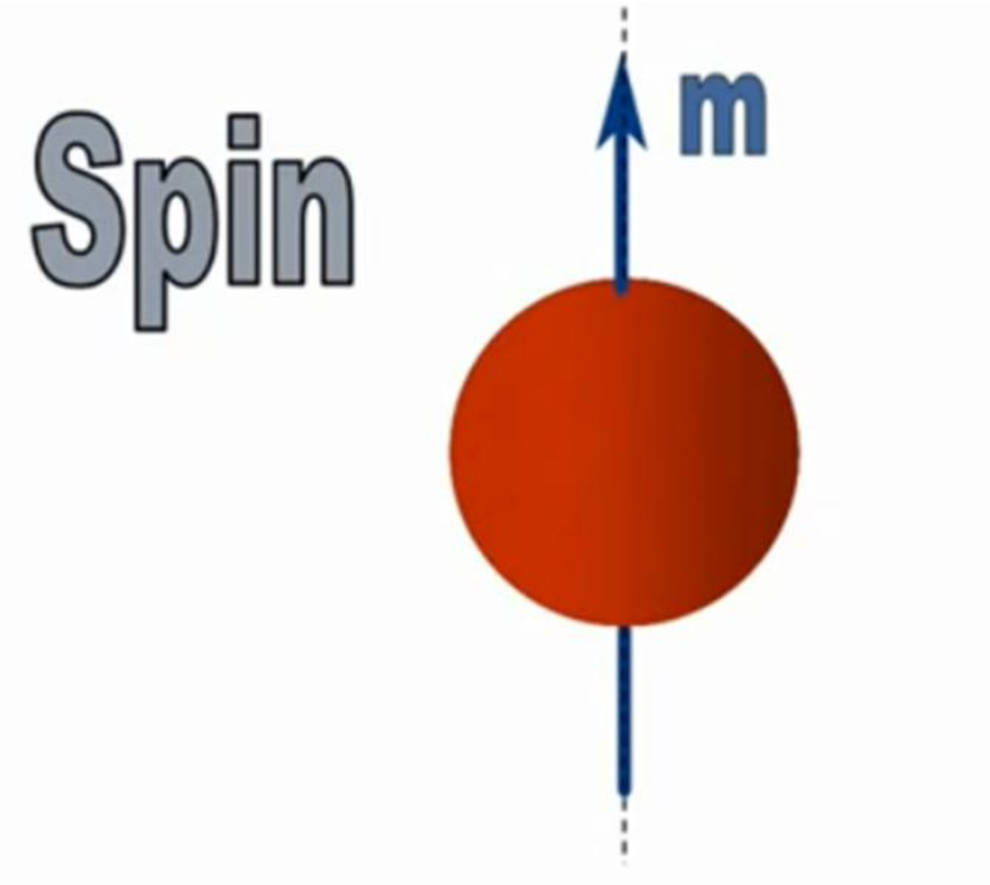

water molecule
hydrogen atom
H
O
H
Proton

- Protons and neutrons, which make up the nucleus of atoms, behave as tiny subatomic magnets due to their spin.

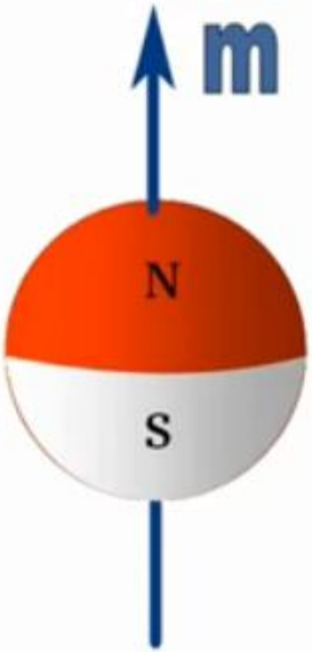
- subatomic “magnets” that are in constant motion and point in different directions.

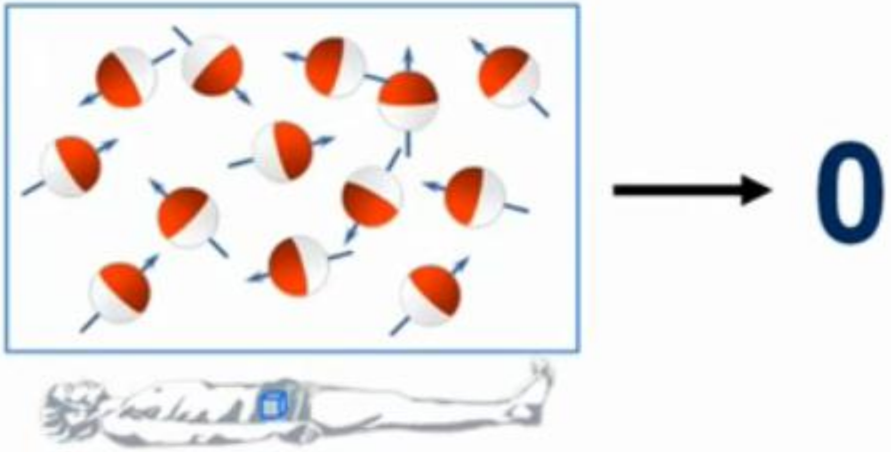
Spin




Spin
m

Spin





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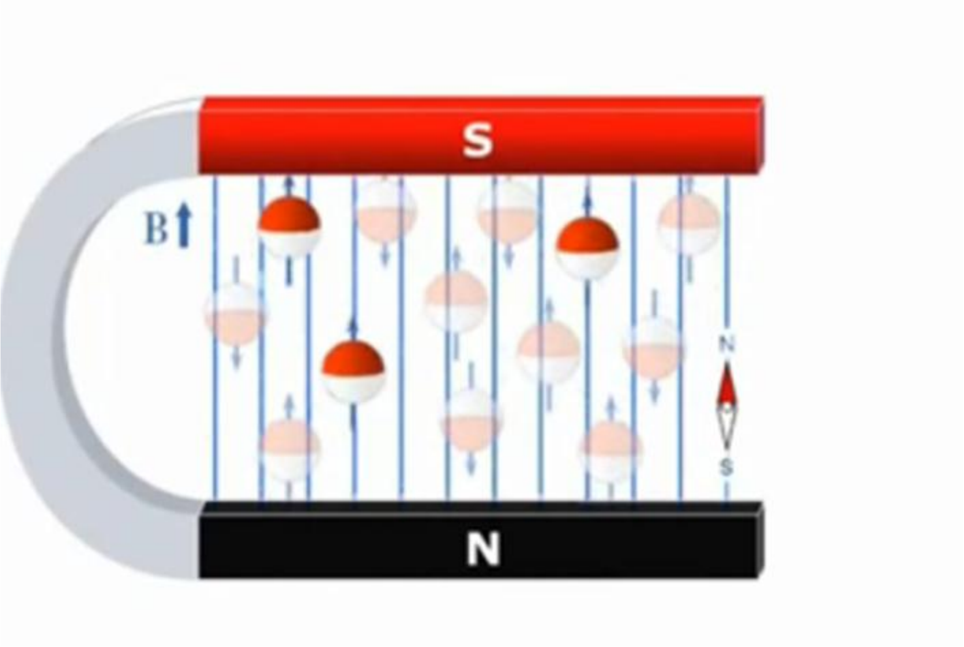
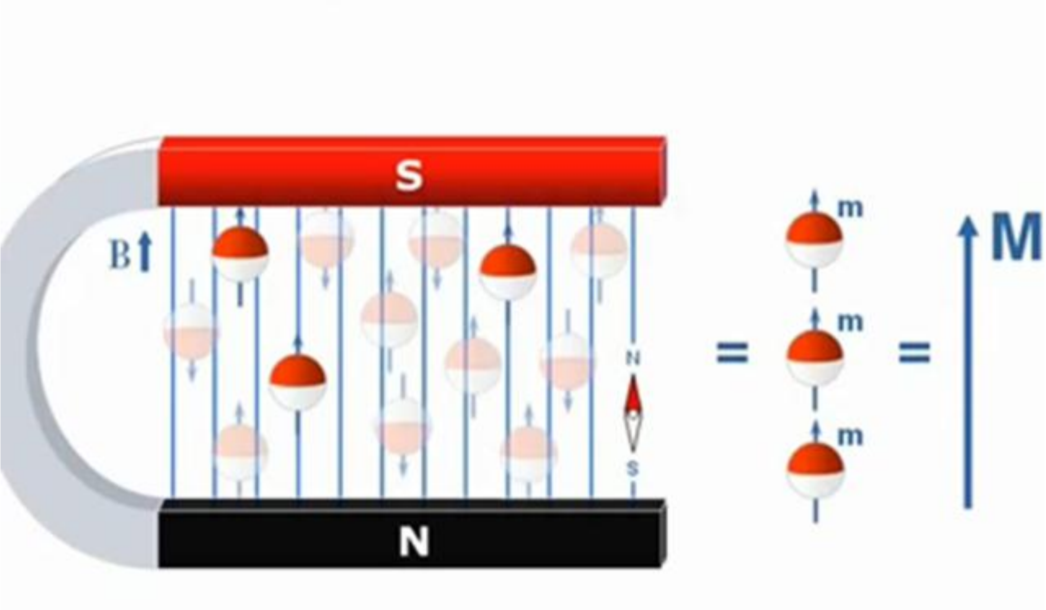
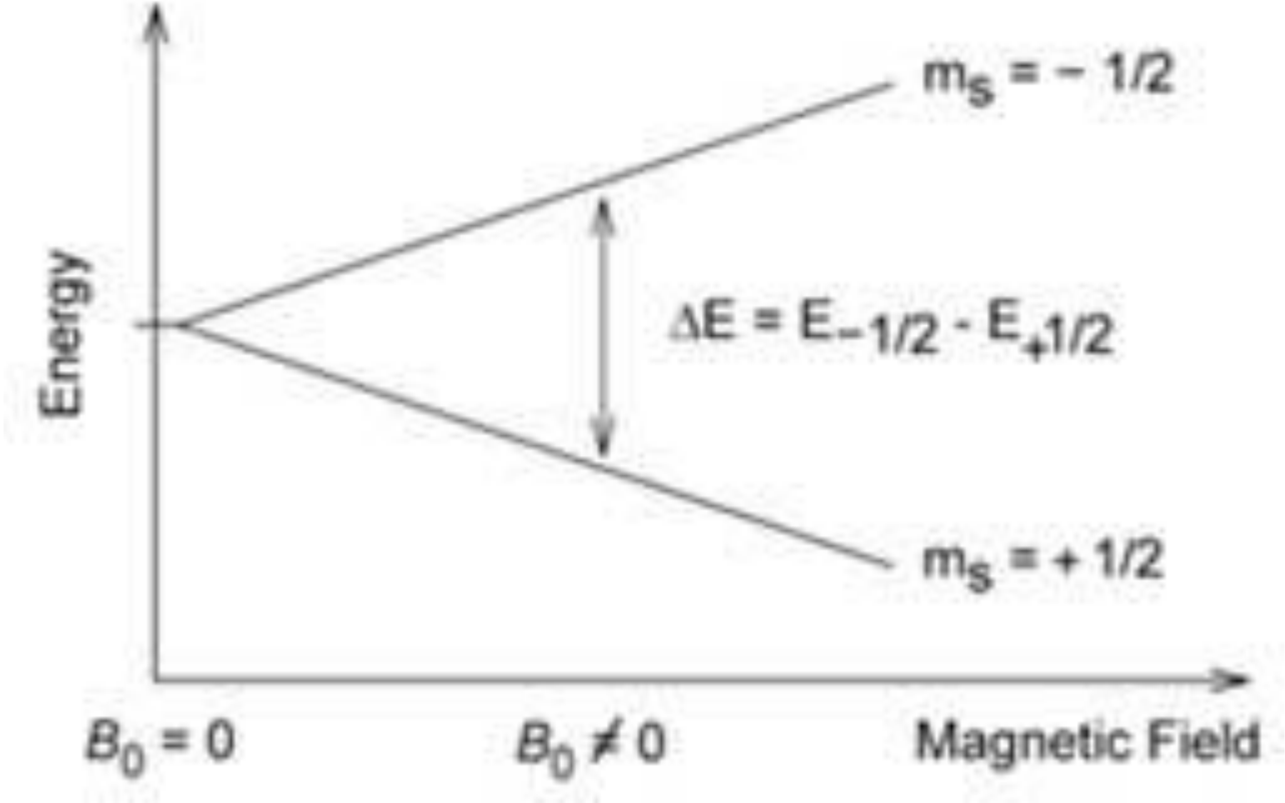
- When a nucleus with an overall magnetic moment is placed in an external magnetic field it will either line up parallel or antiparallel (often termed spin up or spin down) with the external magnetic field, as shown below.

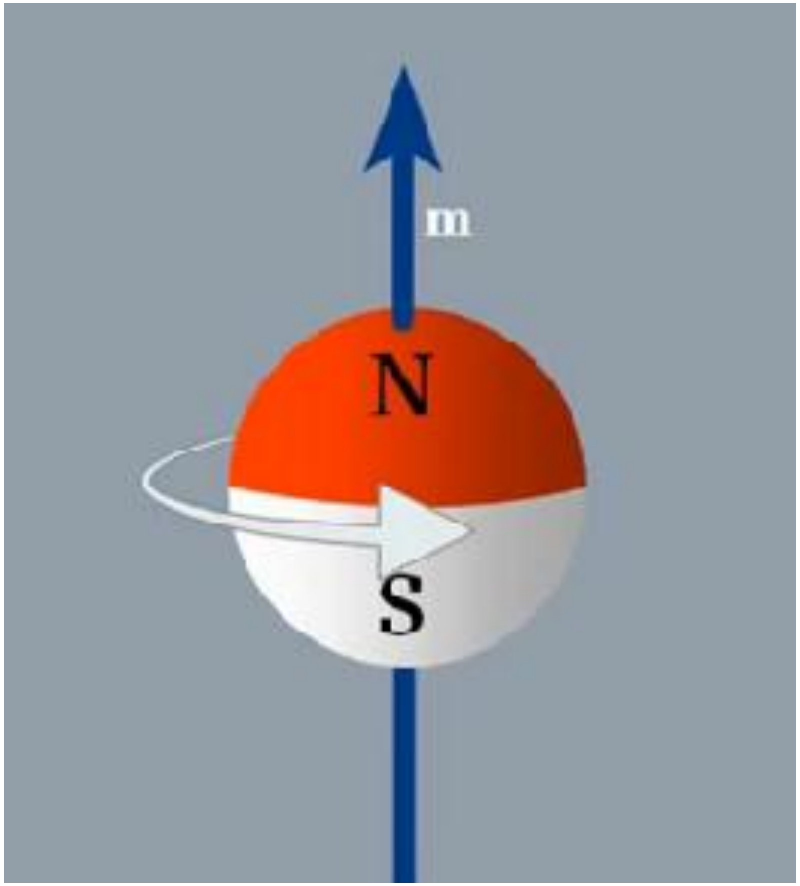

S
B
N
S
N

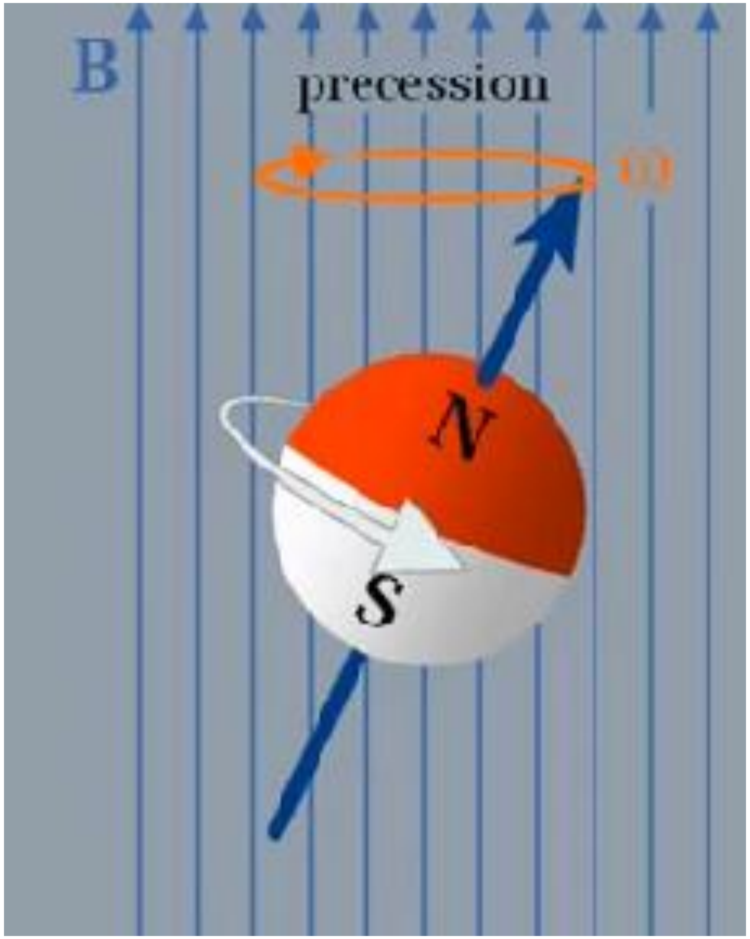

S
B
N
S
N
m
m
m
=
=
M

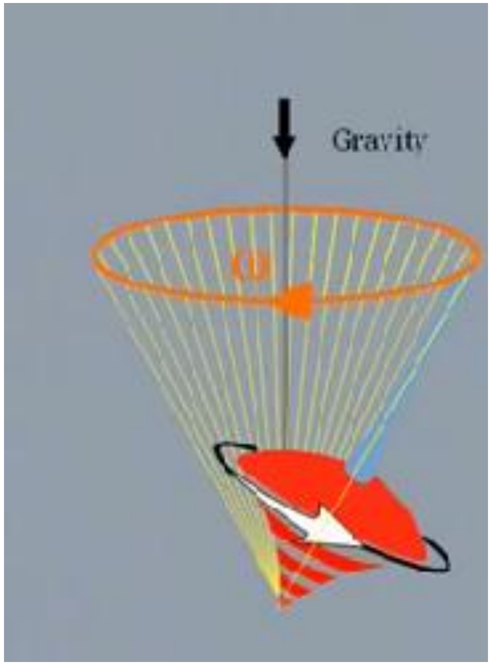
- This defines two energy states that are determined by the type of nucleus and the external magnetic field.
- The difference between these two energy states is proportional to the strength of the external magnetic field that the nucleus is in.

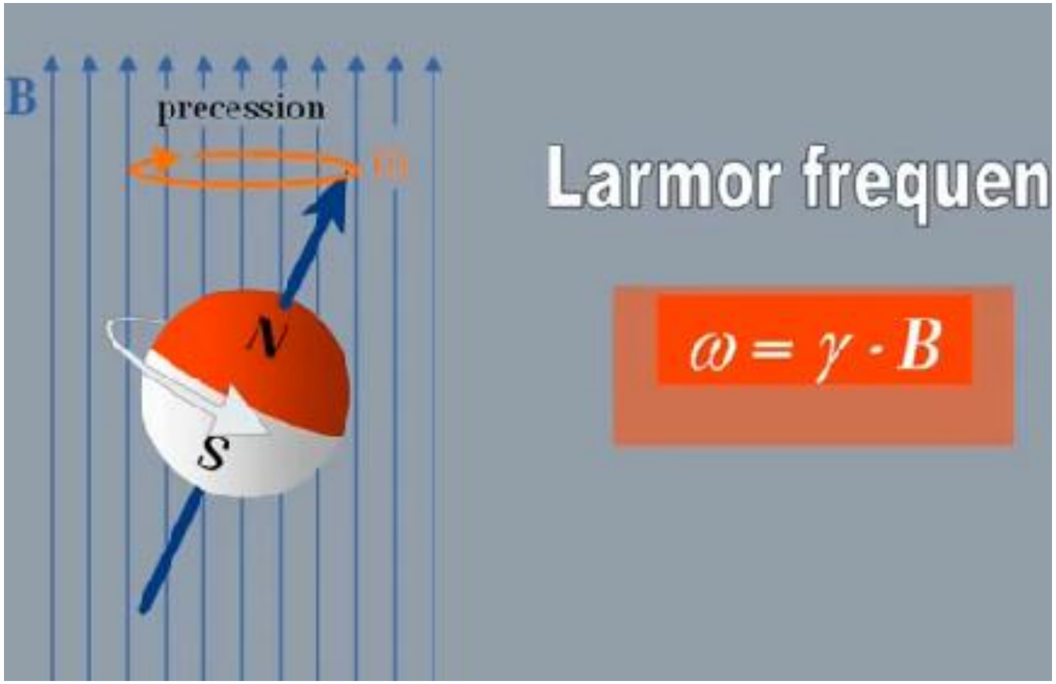


Energy splitting of nuclear spin states as a function of an external magnetic field, B0.ms = +1/2 is the spin up state and ms = -1/2 is the spin down state.


m
N
S


B
precession
ω
N
S

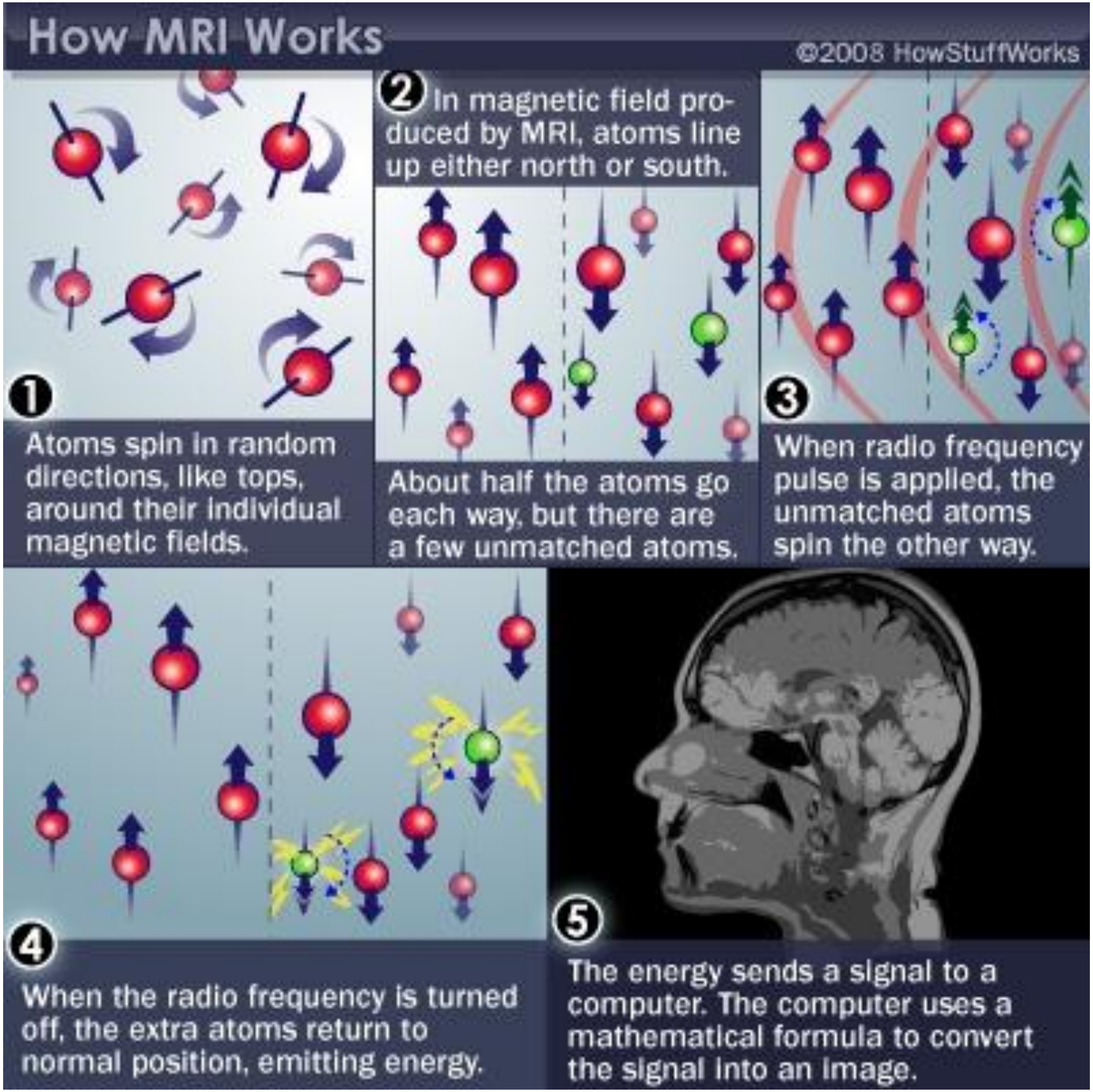

Gravity
ω


B
precession
ω
N
S
Larmor frequen
$\omega = \gamma \cdot B$

Resonance

Excitation

Relaxation



How MRI Works

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1. Atoms spin in random directions, like tops, around their individual magnetic fields.

2. In magnetic field produced by MRI, atoms line up either north or south.

   About half the atoms go each way, but there are a few unmatched atoms.

3. When radio frequency pulse is applied, the unmatched atoms spin the other way.

4. When the radio frequency is turned off, the extra atoms return to normal position, emitting energy.

5. The energy sends a signal to a computer. The computer uses a mathematical formula to convert the signal into an image.

Introduction ✓
Hydrogen atom ✓
Spinning ✓
Precessing ✓
Resonance ✓
Excitation ✓
Relaxation ✓

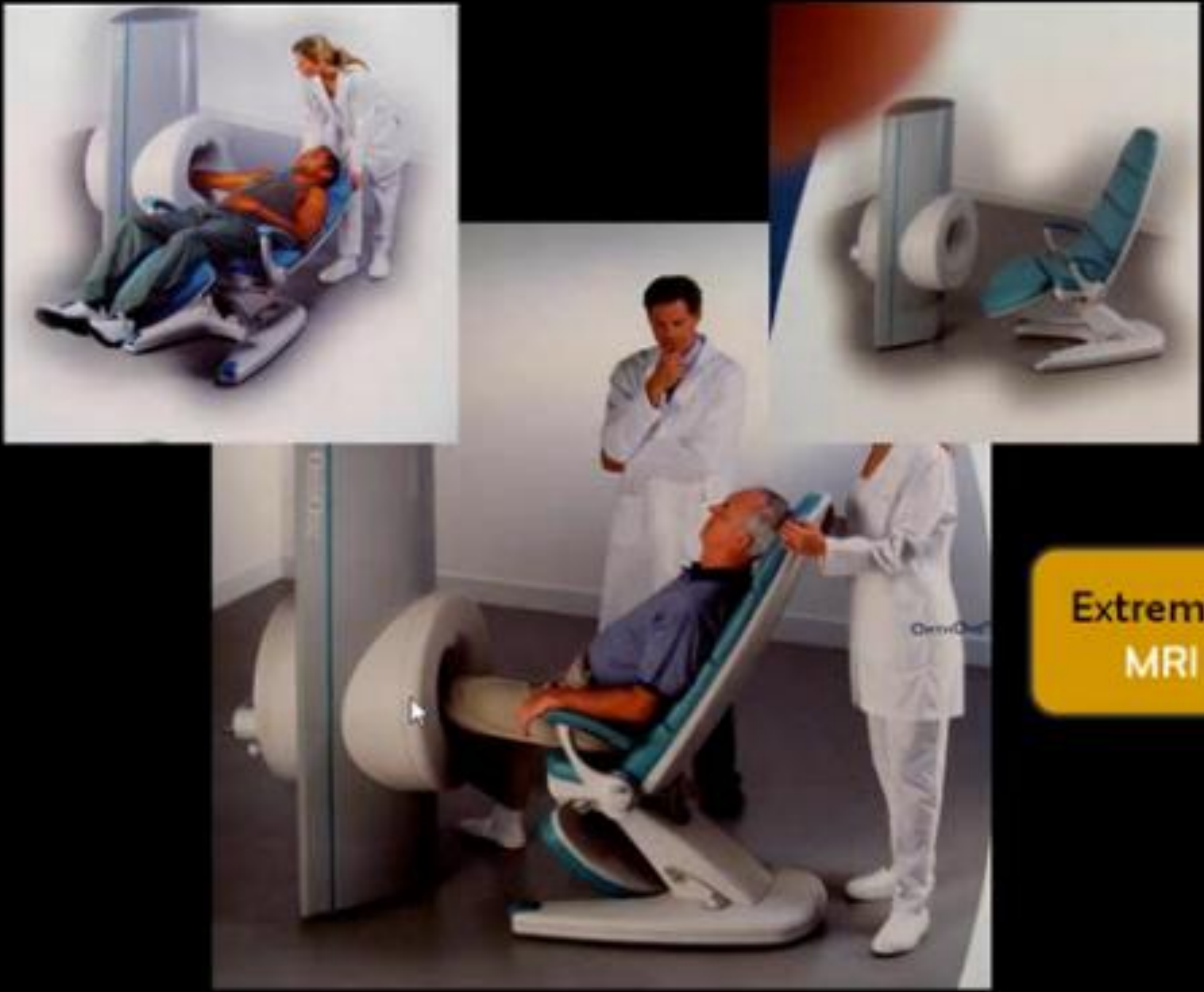
Signal generation ✓

The machine

- The strength of the magnet varies from 0.5 – 4 tesla
- Average cost between 1-2.5 million

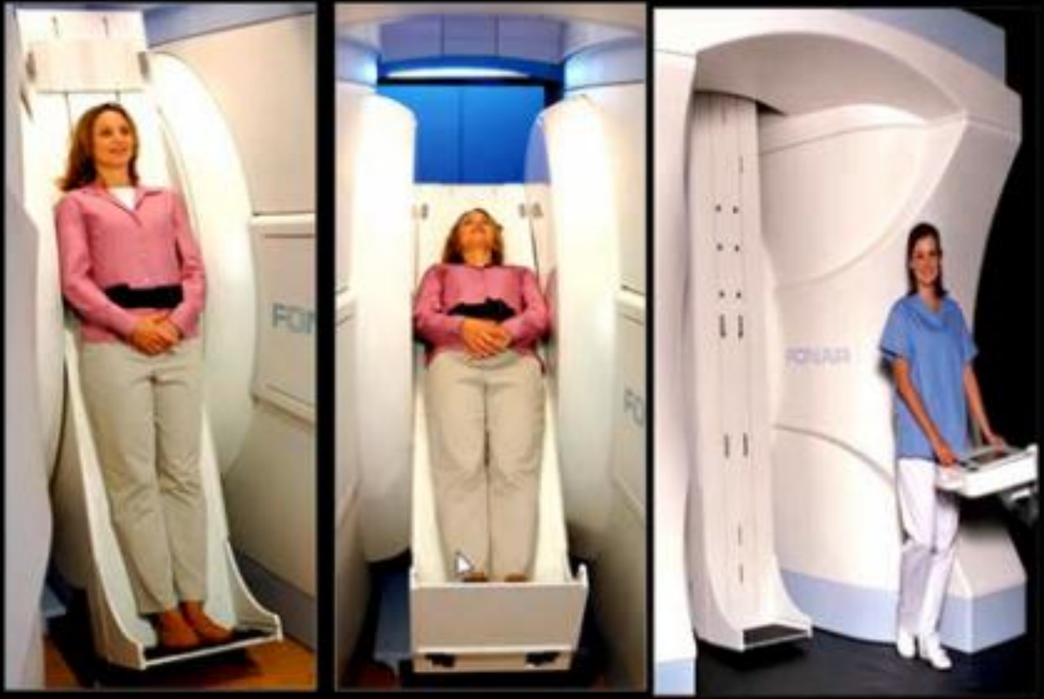
MRI
Open

MRI
Closed



Extremity MRI

Dynamic MRI



The bed rotates from Upright to Recumbent, stopping at any angle in between

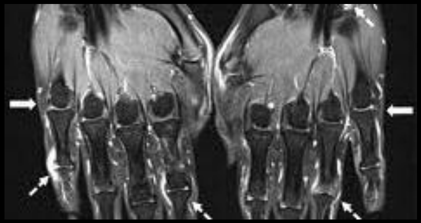
Dynamic MRI

MRI Advantages

- MRI is particularly useful for the scanning and detection of abnormalities in soft tissue structures in the body like the cartilage tissues and soft organs like the brain or the heart.
- There is no involvement of any kind of radiations in the MRI, so it is safe for the people who can be vulnerable to the effects of radiations
such as pregnant women or babies.

MRI Advantages

- MRI scan can provide information about the blood circulation throughout the body and blood vessels and also enabling the detection of problems related to the blood circulation.

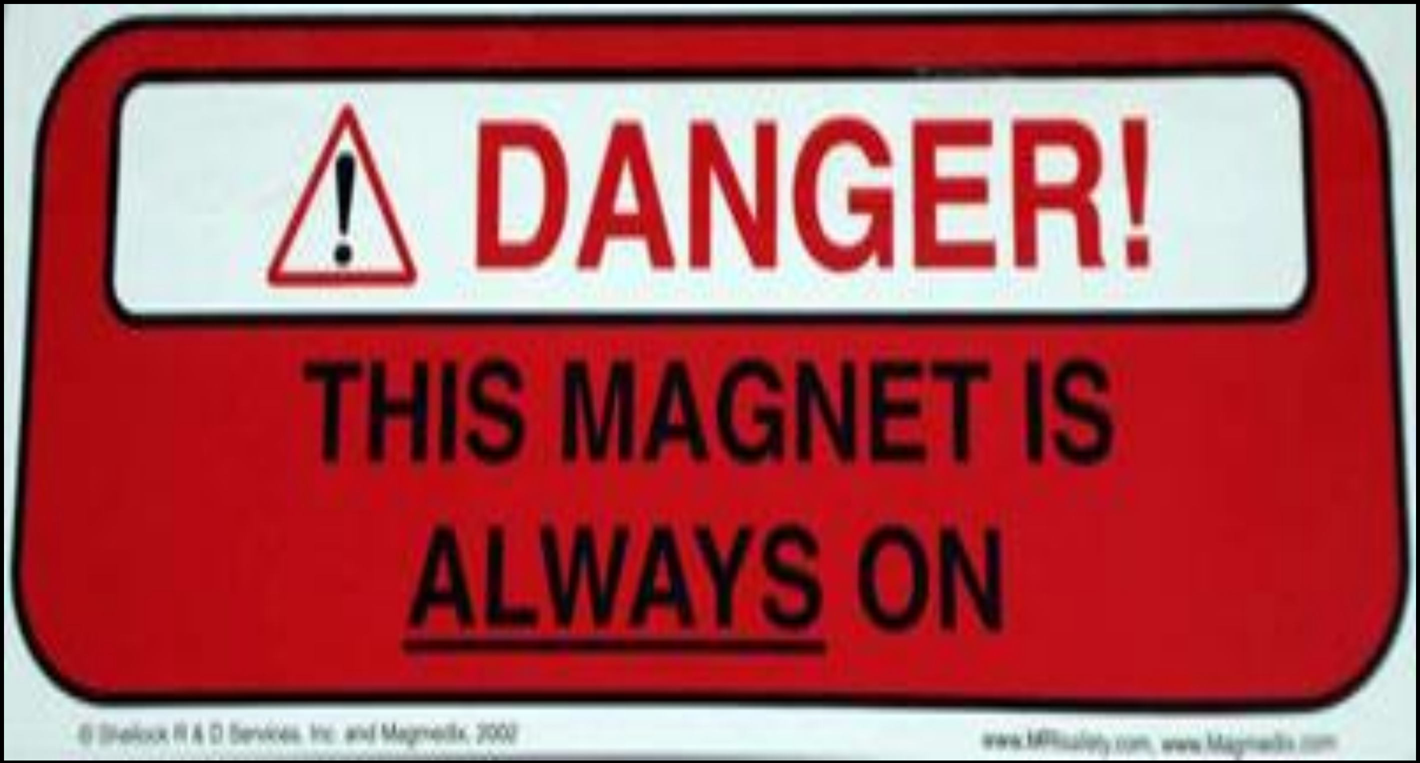


Uses for an MR

Used to image a large variety of tissues and substances.

  - Brain imaging: to define anatomy, identify bleeding, swelling, tumors, or the presence of a stroke
  - To locate glands, organs, joint structures, muscles and bone

- Some diseases manifest themselves in having an increase in water content.
- The MRI can detect inflammation (tumors) in many tissues
- Helpful in diagnosing problems with eyes, ears, heart, circulatory system, lungs, pelvis, spinal cord, etc.



⚠ DANGER!

THIS MAGNET IS
ALWAYS ON

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Potential Projectiles: Examples

- **Cell phone**
- **Keys**
- **Glasses**
- **Hair pins / barrettes**
- **Jewelry**
- **Safety pins**
- **Paper clips**
- **Coins**
- **Pens**
- **Pocket knife**
- **Nail clippers**
- **Steel-toed boots / shoes**
- **Tools**
- **Clipboards**
- **No loose metallic objects should be taken into the Scan room!**

Thank you for your attention